7th. Emersion of the 3d satellite of Jupiter observed at 8^h 23′ 15″ mean time, *very clear.*

By Mr. Delambre's tables, the longitude of Lancaster as deduced from each of the foregoing observations on the eclipses of Jupiter's satellites will stand as follows.

					Longitude West from Greenwich. h ′ ″
1804.	March	11th.	Immersion of the	2d satellite	5 3 58
	May	13th.	Emersion of the	1st ditto.	5 5 36
		20th.	ditto.	1st ditto.	5 5 15
		22d	ditto.	3d ditto.	5 5 9
	June	5th.	ditto.	1st ditto.	5 5 20
		28th.	ditto.	1st ditto.	5 5 11
	July	4th.	ditto.	3d ditto.	5 5 0
1805.	April	30th.	Immersion of the	1st ditto.	5 5 32
	June	1st.	Emersion of the	1st ditto.	5 5 43
		2d.	ditto.	2d ditto.	5 4 51
	July	4th.	ditto.	2d ditto.	5 4 36
		10th.	ditto.	1st ditto.	5 5 55
		11th.	ditto.	2d ditto.	5 5 11
		17th.	ditto.	1st ditto.	5 5 45
		26th.	ditto.	3d ditto.	5 4 34
	Aug.	2d.	ditto.	1st ditto.	5 5 53
		do.	Immersion of the	3d ditto.	5 2 54
		9th.	Emersion of the	1st ditto.	5 5 50
	Sep.	6th.	ditto.	2d ditto.	5 5 22
		7th.	ditto.	3d ditto.	5 4 42

No. XXXIX.

A Description of a Cave on Crooked creek, with Remarks and Observations on Nitre and Gun-Powder, by Samuel Brown, M. D. of Lexington, Kentucky.

Read February 7th, 1806.

THERE are few works on Natural History or Chemistry which do not contain some facts or opinions concerning the formation and properties of nitre. To recapitulate these facts,

or to state the various theories to which they have given rise, would be a task very different from that which I have undertaken; which is merely to communicate a short account of some of the most remarkable caverns and rocks from which that salt is obtained in Kentucky; and to offer some conjectures relative to the causes of the imperfection of the gun-powder manufactured in the United States.

The quality of the nitre procured from the earth in calcareous caverns, is universally believed to be different from that which is found in the sand rocks. I have not been able to ascertain, with any degree of precision, the quantity annually manufactured in this State, nor the number of caverns which are known to contain it. I have however visited several of the most remarkable of them and from the best information I could procure I have formed the following estimate.

	lb of Nitre.
The great cave on Crooked creek, a branch of Rock castle, supposed to contain - -	1000000
Scott's cave, two miles distant from the great cave	200000
Davis's cave, six miles distant from the great cave	50000
Two other caves, within a mile of the great cave	20000
A cave on Rough creek, a branch of Green river	10000

Besides these, which I have had an opportunity of examining, I have heard of many others in various parts of the State; some of which are esteemed very rich in nitre, and are said to be of great extent.

The great cave on Crooked creek in Madison county, is situated about 60 miles south east of Lexington. It has two mouths which are 646 yards distant from each other, and about 150 yards from a large creek, which winds round the hill through which the cave affords a commodious passage for horses and waggons. The general level of the floor of the cave is 80 feet above the creek. The average height of the arch is ten feet, though in many places it rises to fifty or sixty. The breadth of the passage is generally about forty feet, in some parts it is seventy or eighty feet. The floor has the appearance of a large public road, which has been much frequented. The ceiling is in most places smooth, with but few incrustations or stalactites. In some of the chambers however there are appearances

of Gothic rudeness and irregularity which are truly sublime. When these vast chambers are sufficiently illuminated by the torches and lamps of the workmen, they present scenes so uncommon and so romantic, that the most stupid beholder cannot contemplate them without expressions of the greatest astonishment. During the winter season the effect of these scenes is greatly increased by a stream of water which issuing from a small opening in the arch of the cave, about twenty feet above the floor and falling into a bason, occasions a noise which in these calm regions can be heard at great distance, and echoing from arch to arch, fills the mind with the idea of some mighty cataract*.

The temperature of this cave, during the last winter (the coldest we have had for several years) was generally 52° of F. sometimes the mercury rose as high as 57° but never sunk to the freezing point, when the thermometer was placed at any considerable distance within the cave. In one chamber however, the heat was frequently so great as to be disagreeable. About sixty paces from the south entrance, a passage leading from the main avenue conducts you to this chamber, which is nearly circular and about twenty feet in diameter. The arch over this part of the main avenue and that over the passage leading to the warm chamber, are equally elevated. But the ceiling of the chamber is twenty or thirty feet higher. As you approach the chamber, the floor gradually rises until it ascends above the level of the arch of the passage. As soon as you ascend above that level, you perceive the air uncommonly warm, even when the temperature of the passage is near the freezing point. The air which fills the main avenue in summer and autumn is forced into this chamber, whenever the external atmospheric air becomes so much condensed by cold as

* This cave was discovered about seven years ago by a Mr. Baker. He entered it by the north mouth, but proceeded only a small distance into it, on the succeeding day he brought his wife and two or three of their children to explore it, he carried a torch and his wife a supply of pine. After they had advanced within hearing of this torrent 400 or 500 yards from the north mouth, the only one then known, he dropped his torch and it was completely extinguished. During two days and two nights this miserable family wandered in total darkness, without provisions and without water, though sometimes within hearing of a cataract which they durst not approach, at length Mrs. Baker in attempting to support herself on a rock, perceived that it was wet, she conjectured that this was caused by the mud which they had brought in on their feet, Baker immediately ascended the rock, and saw the light of day.

to rush into the mouth of the cave; and whenever during the winter, any portion of air in the main avenue, where the passage leads off, is accidentally heated by fires, or by carrying torches or lamps through the cave, as this heated air cannot escape by the mouth of the cave (for the arch descends towards the mouth) it ascends into this chamber, and rises to the ceiling, where it must remain until the external air and that in the passage and avenue acquire a higher temperature than the air in the chamber. This chamber then is constructed precisely upon the principles of the Russian vapour bath, so minutely described by count Rumford.

During the winter season, the walls and floor of this cave remain perfectly dry; but in summer, innumerable drops of water collect upon the rocks and trickle down upon the floor which sometimes becomes as moist as a bed of mortar. This is particularly the case during very hot weather when the atmosphere is loaded with vapours. I collected a quantity of the liquid condensed upon the rocks, and found that it possessed the same properties with the liquor obtained by lixiviating the earth on the floor of the cave. It would appear from this fact, that the nitric acid is formed in the cave and is condensed upon the rocks, the lime of which it dissolves. But in what manner this nitric acid is formed, I confess myself wholly ignorant, as there are no substances in a state of putrefaction within the cave which could yield the requisite supply of nitrogene gas. It is to be remarked, that the whole of the water condensed upon the rocks, does not taste of the nitrate of lime. A great part of it is quite insipid, although dropping upon earth which is rich in nitre, and many parts of the cavern have been found so completely filled with clay, that it is not easy to conjecture how it was possible for atmospheric air to reach them, and this clay too, is strongly impregnated with nitrate of lime. The depth of the earth on the floor of this cave has never yet been ascertained. In some places the workmen have dug down fifteen feet and the earth even at that depth still contains nitre. It is commonly supposed that throughout the cave, every bushel of earth contains at least one pound of nitre. In many places it will yield more than two pounds

to the bushel. Formerly the earth was taken out of the cave and lixiviated near the stream, at present hoppers are erected in the cave, and the earth after lixiviation, is left to be impregnated again with nitrate of lime; but what length of time will be requisite to saturate it, has not yet been ascertained.

The workmen have different modes of forming an opinion with regard to the quantity of nitre with which the earth may be impregnated. They generally trust to their taste; but it is always considered as a proof of the presence of nitre, when the impression made on the dust by the hand or foot, is in a very short time effaced. Where the nitre is very abundant the impression made to-day, will be scarcely visible to-morrow. Where there is a great deal of sand mixed with the dust, it is commonly believed that a small quantity of pot-ash will suffice for the saturation of the acid.

The method of making saltpetre usually practised in Kentucky, is as follows.

The earth is dug and carried to hoppers of a very simple construction, which contain about fifty bushels, cold water is poured on it from time to time, and in a day or two a solution of the salts runs into troughs placed beneath the hoppers. The lixiviation is continued as long as any strength remains in the earth. The liquor is then put into iron kettles, and heated to ebullition; it is afterwards thrown upon a hopper containing wood ashes, through which it is suffered to filtrate. As the alkaline part of the ashes is discharged before the nitrate passes through, the first runnings of this hopper are thrown back; and after some time, the clear solution of nitrate of pot-ash runs out, mixed with a white curd, which settles at the bottom of the trough. This clear liquor is boiled to the point of crystallization, then settled for a short time and put into troughs to crystallize, where it remains twenty-four hours, the crystals are then taken out, and the mother-water thrown upon the ash-hopper, with the next running of the nitrate of lime. When the quantity of the nitrate of lime is too great for the portion of ashes employed, the workmen say their saltpetre is in the "*grease*" and that they do not obtain a due quantity of nitre. If there has been too great a proportion of ashes employed,

they say it is in the "*ley*," and when it is left to settle previous to crystallization, a large quantity of salt will be deposited in the settling troughs, which they call "*cubic salts*." These salts are again thrown upon the ash-hoppers and are supposed to assist in precipitating the lime from the nitrate of lime, and in the opinion of the workmen, are changed into pure saltpetre. They consider this salt as nitre *killed*, as they express it, by the excessive strength of the ley. To make 100 pounds of good saltpetre at the great cave, eighteen bushels of oak ashes are necessary; ten of elm, or two of ashes made by burning the dry wood in hollow trees. In the discovery of the value of this latter kind of ashes, the philosophers and chemists of Europe have been anticipated by the saltpetre-makers of Kentucky.* The earth in some caves does not require half this quantity of ashes to precipitate the impure salts.

When wood ashes cannot be readily obtained near the caves, the liquor which runs from the earth in the hoppers is boiled down to the point of crystallization, and suffered to become solid by cooling. In this form, which is called "*thick stuff*," it is transported to a part of the country, where ashes can be procured, dissolved in ley sufficiently strong to precipitate the lime, settled in troughs and then boiled down and crystallized. This thick stuff is extremely liable to deliquesce in warm moist weather, and is therefore commonly melted down and put into casks before it is carried from the caves. Horned cattle are very fond of it, and a small portion of it is almost instantly fatal to them. Those who have had frequent opportunities of seeing cattle perish in this way, remark that the blood when drawn from their veins, is of a very black colour, and flows with great difficulty. A substance possessing such active properties, might deserve the attention of experimental physicians, and may possibly merit a share of that praise which has been so liberally and perhaps so injudiciously bestowed upon the nitrate of pot-ash.

After these observations on the calcareous nitre beds in Kentucky, and the modes commonly employed for obtaining that salt, I shall mention some of the most remarkable circumstan-

* See Vol. X. p. 330. Philosophical Magazine.

ces which have come to my knowledge, relative to the rock ore or sand rocks which yield nitre supposed to possess peculiar qualities.

These sand rocks are generally situated at the head of a ravine or narrow valley, lead up a steep hill or mountain: ascending the streamlets which run through these valleys, the banks close in upon you and become perpendicular. The rocks are frequently from sixty to one hundred feet in height, and jutting over their bases, which rest on a calcareous stratum, often form a shelter large enough to secure a thousand men from the inclemencies of the weather. During the winter season a small rill is precipitated from the top of these rocks, and in summer water generally issues from between the silicious and calcareous strata. These sand rocks which probably once formed a complete upper stratum, have been for ages exposed to the destructive operations of rains and frosts, and as they crumble off are carried by torrents into the plains and rivers beneath. The summits of all the hills in the vicinity of Rock castle, Licking and Sandy are still covered by masses of these rocks, which from their beauty and variety of figure, might at a small distance be mistaken for the ruins of Gothic cathedrals or Baronial castles. Vast blocks of them have rolled down into the valleys, at a period of time so remote, that they are now covered by trees of a luxuriant growth. These rocks when broken perpendicularly, present a surface consisting of strata so irregular, with regard to their position, and so different in colour and in the size of the particles of sand, that it is impossible to doubt of their Neptunian origin. The minute inspection of them never fails of awakening in the mind the recollection of the shore of some vast lake, where the rage of the winds and the waves has piled up hills of sand, which time consolidates into rock.

Several years ago the saltpetre-makers discovered that the sand and rubbish sheltered from rains by these rocks contained a rich impregnation of nitre, and that only a small portion of ashes was necessary for its purification. They soon after found that the sand rock itself tasted strongly of saltpetre, and immediately commenced the new method of working.

After blowing off large blocks of the rock, they break them into small pieces with hammers, and throw them into kettles containing boiling water; as soon as the rock falls into sand by the action of the hot water upon it, they put it into hoppers and wash out all the nitre by frequent additions of cold water, this solution is boiled down and crystallized without any mixture of ashes or pot-ash. Sometimes when the mother-water has been very often added to fresh solutions of the nitre, they find it necessary to use a very small quantity of ashes.

I have been informed by a Mr. Fowler, that he and his associates have made saltpetre at twenty-eight different rock houses or caverns, from which they have obtained about 100000 pounds of nitre, all these are situated on the north side of Kentucky river, within seventy miles of Lexington. He remarks that he has never seen a rock facing the north or west, which was very rich in nitre. He has always desisted from working a rock when it failed to yield him ten pounds to the bushel of sand. He has often obtained twenty or thirty pounds per bushel. He assured me that he once discovered a mass of very pure nitre, which was found to weigh 1600 pounds. Mr. Foley, another saltpetre-maker, found one containing 100 pounds; another mass was found on Rock castle, which report says weighed 500 pounds. I have now in my possession a solid mass of native nitrate of pot-ash of singular purity, which weighs three pounds, it is more than four inches in thickness, and is only a small portion of a block of nitre found last summer on Licking river, I have likewise a number of smaller specimens, which I myself procured from the different caves which I visited some weeks ago. These are generally found between the rocks which have fallen from the cliff, or the crevices of those rocks which still remain in their primitive situation. The rocks which contain the greatest quantity of nitre are extremely difficult to bore, and are generally tinged with a brownish or yellow ocre colour. Sometimes they contain an oxide like manganese, and sometimes great quantities of iron ore, which resembles the bark of the scaly bark hickory, surrounded by a finely powdered brown oxide. At some of these rock houses three hands can make one hundred pounds of good

nitre daily, but forty pounds may be considered as the average product of the labour of three men at those works which I had an opportunity of visiting.

The workmen being badly provided with tools and apparatus, desert a rock whenever its size or hardness renders it difficult for them to manage it, and go in quest of a new establishment. Several caves and rocks which these strolling chemists have deserted, still contain many thousand pounds of nitre. These men are continually searching for masses of pure nitre, or rich veins of ore, by which much of their time is unprofitably dissipated. Still however most of our saltpetre-makers find it their interest to work the sand rock rather than the calcareous caverns, which last yield a mixture of nitrate of pot-ash and nitrate of lime. The rock saltpetre is greatly preferred by our merchants and powder-makers, and commands a higher price.

Mr. Barrow, in his travels through the southern parts of the continent of Africa, discovered native nitre, which is probably similar to the rock saltpetre of Kentucky. But Bowles, Dillon and Townshend assure us that those districts in Spain, which afford nitre most abundantly, contain neither chalk, limestone, gypsum, nor any other calcareous substance. The nitrate of pot-ash is obtained there by filtrating a certain kind of black mould which will continue for ages to yield annual supplies of it, together with muriate of soda, sulphate of magnesia, nitrate and sulphate of lime. Here then appears to be such a relation existing between the different saline substances, both acids and alkalies, that the causes which produce one of them, owing to some yet undiscovered circumstance, regularly produce all the rest. According to these authors the same mould will continue forever to yield these salts annually. This observation if correct, would induce us to believe, that both acids and alkalies are wholly formed from atmospheric air and not from the soil; as the soil would certainly be exhausted if any considerable portion of it entered into the composition of either the acids or alkalies, and would soon lose its power of attracting from the air the other constituent principles of the salts. Both in Spain and India, we are informed, that the mould which for fifty years in succession has yielded nitre, still con-

tinues to afford it in undiminished quantities. But how shall we reconcile this fact with that before related concerning the production of nitre in the cavities of calcareous mountains which are, in many instances, so closely filled up with clay, that the air can have no access, from which every ray of solar light is excluded, and where the temperature can never exceed 57° of Fahrenheit? Is it absolutely certain, that nitre formed by natural processes so very dissimilar, possesses no properties necessarily resulting from the circumstances attendant on its formation? That all the nitrates of pot-ash with which we are acquainted, have certain properties in which they agree, is unquestionable, but the same may be said of lime and barytes, of soda and pot-ash, and many other substances, which in the early ages of chemical science, were probably identified. Hoffman, long ago proved, that nitrate of pot-ash afforded an alkali very different from that of wood ashes or salt of tartar. The observations of so distinguished a philosopher deserve much attention, and his experiments if repeated by modern chemists could scarcely fail of affording important results: that the sand rock saltpetre differs from that procured from the calcareous caverns, in the form of the crystal, in hardness and dryness, is known to all who deal in that article, and every powder-maker affirms that it makes better gun-powder. Whether this superiority is owing merely to its greater purity or exemption from an admixture of nitrate of lime, or whether the constituent acid and alkali are modified in some unknown manner, is yet altogether problematical. Chaptal, Thouverel, Guyton, and indeed most of the modern chemists, suppose, that pot-ash is a compound of lime and hydrogen, and that lime itself is formed of carbon, azote and hydrogen, and consequently that pot-ash consists of hydrogen, carbon and azote. Mr. Guyton thinks that soda is composed of magnesia and hydrogen, and that magnesia is a compound of lime and azote, and therefore, that soda is made up of hydrogen, carbon and azote. He is then of opinion that pot-ash, soda, lime and magnesia are nothing more than varied forms and proportions of the same constituent ingredients, differing from each other in the quantities and forces of attraction. This opinion de-

rives great probability from an experiment of Bishop Watson, by which it would appear, that soda was actually converted into pot-ash. It is likewise corroborated by the apparent conversion of lime and soda into pot-ash in our calcareous caverns, and by the change of what the workmen call *cubic salts*, into nitrate of pot-ash. Thouverel affirms that he witnessed the real conversion of washed chalk into pot-ash, in his experiments on nitrous vapours, and Chaptal observed the same phenomenon when exposing chalk to the vapours of putrid bullock's blood. Now as the nitric acid combines readily with lime, soda and magnesia, as well as with pot-ash, it may be easily conceived, that it still retains its affinity for those substances, in every form which they may assume, whilst changing into each other, and that the "*tertium quid*" formed by the union of nitric acid and lime *in the intermediate stage between lime and pot-ash*, may possess properties very different from nitrate of lime or nitrate of pot-ash. The same may be remarked with regard to soda and magnesia. Here every chemist will recollect the ingenious observations of Dr. Mitchel, concerning nitric acid and the essential differences between that substance and septic acid at the moment of its formation. No person can doubt of the possibility of charging nitrogene with different portions of oxegen. The explosive efficient property of nitre may depend on a certain dose of this principle. But even admitting that pot-ash and nitric acid never vary in their nature, it may still be contended, that powder-makers have no means of ascertaining what proportion of acid and alkali that nitre ought to contain, which would form the best gun-powder. And whilst this is confessed, it surely can avail us little, to be very scrupulous in the adjustment of the proportions of the nitre to the charcoal and sulphur. The consumers of pot-ash, in every part of the world have remarked varieties in the quality of the salt, for which no particular cause can be assigned. It is very much to be regretted, that a regular series of experiments has never been instituted, to discover what kind of ashes would yield an alkali most proper for the formation of nitre. Charcoal should be examined with a similar view. Mr. Coleman has published experiments and remarks

on this subject, (Philosophical Magazine, V. IX. p. 355.) which appear to me very interesting. By his mode of distilling wood in iron cylinders, he deprives it completely, of all the volatile oil, hydrogenous gas and pyroligneous acid. The charcoal prepared in this way, possesses uniformly the same properties, and by the employment of it, the powder now used in the British ordnance, is increased in strength one third.

The gun-powder manufactured in the United States, is said to be defective, from a disposition either to effloresce or deliquesce. The salts most liable to effloresee are such as have soda for their base. In many of our saltpetre caves, small quantities of the sulphate of soda have been discovered, which for want of sufficient care or skill in refining, are suffered to remain with the nitre. The disposition to efflorescence appears to be directly opposite to that of deliquescence; as in the one case, the air has a stronger affinity for the water of combination of the salt than that which exists in the salt for the water; in the other case the salt attracts moisture from its combination with air. It would seem then, that, as the air is capable of depriving the sulphate of soda of its water of combination, and as nitrate of lime attracts moisture from the surrounding air, it is possible, that a mixture of these two salts may be so made with nitrate of pot-ash, that the nitrate of lime may deprive the sulphate of soda of its water of combination, and in consequence of this addition of water, deliquescence may ensue, even when the atmospheric air and moisture are excluded. If Count Rumford is correct in supposing that the explosive force of gun-powder depends not upon the evolution of permanently elastic fluids or gases; but upon the almost instantaneous conversion of the water of combination existing in the powder, into steam by the caloric resulting from its inflammation; this explosive force may be diminished for want of that water which might have escaped by *efflorescence*, or on account of the slow combustion of the powder consequent on *deliquescence*.

A concern for the glory and defence of our country should prompt such of our chemists as have talents and leisure to investigate this interesting subject. In 1776, at the request of

M. Turgot, the celebrated M. Lavoisier was appointed superintendant of the French national powder works, and with what success he executed the duties of his important commission the history of their subsequent naval campaigns have sufficiently evinced. The efforts of European chemists, seem to have been principally directed to the removal of the marine salt which the nitre of Spain and India contains in great quantities. In the nitre of Kentucky, I have never detected a particle of that salt, and I am confident, that if any is found in it, the proportion must be very inconsiderable indeed. The rock saltpetre I am persuaded, would, with very little refinement, make gun-powder capable of retaining its efficient properties during the longest voyages, as I have never discovered, in that species of nitre, the smallest tendency either to deliquescence or efflorescence.

It will be observed, that I have not in this paper, hazarded any opinion with regard to the formation of nitre in our sand rocks. I freely confess that I have no theory on that subject which is satisfactory to my own mind, I am even disposed to suspect, that our greatest chemists have still much to learn with regard to this salt, so valuable in time of peace, so indispensable in time of war.

No. XL.

An Essay on the vermilion colour of the blood, and on the different colours of the metallic oxides, with an application of these principles to the arts. By Samuel F. Conover M. D.

Read June 20th, 1806.

On the Vermilion colour of the blood.

THESE subjects have excited the attention of some of the most eminent philosophers of the last and present century, though little progress was made in the explanation of these phenomena, previously to the institution of the *pneumatic philosophy*, when truth burst forth upon mankind, dispelled the